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ABSTRACT

Although many researchers expected the psychological effects of the accident at the Three Mile Island (TMI) nuclear plant to be short-lived, area residents continued to show elevated levels of stress. To examine stress levels of TMI residents 28 months after the accident, 141 subjects were chosen from nearby areas, and from a town 80 miles away. Two control groups were selected from residents living near a coal-fired power plant and from those living near an undamaged nuclear plant. Self-reports of psychological stress were collected, and two behavioral measures (Towers of Hanoi and a proofreading task) were administered. Physiological stress was measured by analyzing urine samples for levels of epinephrine and norepinephrine, two hormones found to be related to stress. Results indicated that TMI residents continued to report more stress; more somatic complaints; and more problems with concentration, anxiety, alienation, suspicion, fear, and depression than controls. TMI residents experienced more difficulty than controls with persistence and concentration, and had higher levels of epinephrine and norepinephrine. Residents who reported lower perceived control reported the most symptoms. (JAC)

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Chronic Stress and Three Mile Island: Toxic Exposure and Uncertainty

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The accident at the Three Mile Island Nuclear Power Station (TMI) occurred more than five years ago. Although many researchers expected the psychological effects of the accident to be short-lived, the consequences of it still remain. It is commonly accepted that the accident as well as the two week emergency period which followed it were stressful. During this time acute stress effects such as demoralization and heightened symptom reporting were shown by a number of researchers (Dohrenwend, Dohrenwend, Kasl, & Warheit, 1979; Flynn, 1979). These effects did not dissipate following the emergency period, and our research has found evidence of chronic stress up to 28 months after the accident. One possible reason for the persistence of problems at TMI may be related to the technological nature of the accident. Because the power plant generates nuclear power and the accident involved radiation release, many residents feared that they were exposed to radiation. As clean-up of the damaged plant continued and still continues, the fear of additional radiation exposure remains. Many of the residents also may be unsure of what the future consequences of the possible radiation exposure might be. Therefore, the the toxic nature of the accident may have made it a source of continued stress for TMI residents.

In the present paper data will be presented that show that up to 28 months after the accident, TMI area residents continued to exhibit higher levels of stress than did people in our control groups. Next, some some possible reasons for the persistent stress will be examined.

A total of 141 subjests participated in the study.

Fifty-four subjects were selected in a quasi-random fashion from neighborhoods within five miles of TMI. Another thirty-one were selected from Frederick, Maryland, a town at least eighty miles away from TMI. Two other control groups were selected. One group of 24 subjects lived within 5 miles of a coal-fired power plant. This group lived in Dickerson, Maryland. The final group lived in New Jersey. This group of 32 subjects lived within 5 miles of the undamaged nuclear reactor at Oyster Creek. In all areas streets were randomly selected and every third house approached. Response rate was 75% at all sites.

We have been able to document a persistent stress response in our TMI sample for at least 28 months after the accident. In order to assess this stress response a multilevel research strategy was employed. This method involves the simultaneous assessment of psychological, behavioral and physiological indices of stress.

Self-report measures of psychological stress were collected which included anxiety, depression, somatic complaints and alienation. Two behavioral measures of stress were also obtained. One, called the Towers of Hanoi was used to measure persistence. The task is set up such that there are three pegs of wood on a board. On one of the pegs are a group of 6 rectangular pieces of wood placed so that they form a pyramid. Subjects are asked to move the pyramid to another peg one piece of wood at a time. At no point may they put a longer piece of wood on top of a shorter one. The solution is not that difficult but typically requires persistence if a subject is not familiar with it. The second behavioral measure, proofreading, was used

to assess ability to concentrate. Subjects were given five minutes to read and correct errors in a seven page passage. This task was similar to the one used by Glass and Singer (1972) in their studies of noise and stress.

Physiological measures of stress were obtained by assaying urine samples of subjects. Samples were obtained by collection over a fifteen hour period (between 6p.m.one evening and 9a.m. the next morning). The urine was later examined for the levels of epinephrine and norepinephrine. These two hormones have been found to reflect stress related arousal (Frankenhauser, 1975).

In past sessions, 17 and 22 months after the accident, TMI area residents exhibited more stress by reporting more distress on the self-report measures (Baum, Gatchel, & Schaeffer, 1983). This was again the case. In fact, TMI residents reported more symptoms in general.

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table 1

Specifically, they reported more somatic complaints and problems with concentration, they also reported more anxiety, alienation, suspicion, fear and depression.

Behavioral measures also indicated that TMI residents experienced more difficulty with persistence and concentration than control area subjects. Overall, they spent less time working on the tower task and they made fewer moves. Performance on the proofreading passage also indicated a deficit on the part of TMI subjects. Overall, TMI residents found fewer of the inserted errors than did Frederick, Dickerson or Oyster Creek

subjects.

As for the biochemical indices of stress, TMI area residents had higher levels of epinephrine and norepinephrine than all control area subjects.

Clearly, psychological, behavioral and biochemical indices of stress indicate that TMI residents still show stress 2 1/3 years after the accident. One possible explanation for this effect might relate to the nature of the accident. In particular, the event was technological and we believe that the effects of technological disasters may be different than those associated with natural events. (Baum, Fleming, & Davidson, 1983). This distinction may have implications for people's perceptions of control after the occurance of a disaster. Further, the event posed the threat of radiation exposure, and the involvement of toxins such as radiation may dramatically alter the nature of an event.

In some ways, the accident at TMI was unprecedented. The cause of this disaster was not an act of nature like a tornado or a blizzard, but rather was a reflection of human error. Over the years we have created a vast network of technology in order to improve our lives. Unfortunately, our ablitity to regulate this technology has not always kept pace with our advances. For example, it still seems impossible to predict when technology will break down. Hence, emergency procedures are often not perfected. This seemed to be the case at TMI. Although people expect to encounter storms or other types of natural events once in a while, technological mishaps are not anticipated in the same way. It is possible that these differences may influence

people's perceptions of control. Because perceptions of control influence the stress response it is an important variable to consider as a mediator of the stress experienced by the residents at TMI.

Technological disasters may threaten control in a different way than do than natural disasters. This may be because they represent a loss of control over something that at one time seemed to be under control. Natural forces are not ever under control, so destructive storms and the like are not a loss of control but a lack of control. Research has explored many aspects of control, but for considering stress, one of the most important findings is that the impact of an event is influenced by the perceived controllability of the event. If one believes that one has control over an aversive condition, even if control is not real or is never used, subsequent stress will be reduced. In addition, loss of control may be a stressor. Therefore, the affects and aftereffects of technological disasters may be greater than those of natural disaster. It is for these reasons that we felt that control might be responsible in part for the stress experienced by our TMI subjects.

We have some evidence which suggests that TMI residents perceive themselves as having less control over their surroundings than do comparison subjects. Three questions were used in order to assess different aspects of perceived control. Subjects were asked to indicate how often they experienced feelings of helplessness, how often they felt that it did not matter what they did when given choices, and how often they felt that they did not care whether they did one thing or another. In

fact, TMI subjects reported more feelings of helplessness than did all of the comparison groups, and more often reported feeling that it didn't matter what they did when given choices. Similarly, they felt more frequently that they did not care whether they did things one way or another. These data seem to indicate that residents at TMI were experiencing more control-related problems than were subjects from the other groups.

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table 2

To follow this up, we examined the relationship between control and stress. It was hypothesized that subjects experiencing control related- problems would also exhibit more symptoms of stress. TMI area subjects who were experiencing control related problems should show the greatest amount of stress. In order to test this hypothesis, subjects were placed in groups based on their responses to the three questions which were used to assess perceived control. These grouping were then crossed with residence (TMI, verses all the other control groups combined) and analyses were performed using measures of stress as dependent variables

Self-reported symptoms of stress indicated that TMI area residents who reported lower perceived control reported the most symptoms. They also indicated experiencing the most somatic distress, and depression.

The behavioral data showed similar results. Both the Towers of Hanoi and the proofreading task showed patterns which were

similar to the self-report measures. Findings for persistence, measured as both time spent on the tasks and number of attempts made, showed that the TMI subjects who were low on the control variable also were the ones to spend less time on the task. They also made fewer attempts at solving it. Similarly, these same people found fewer of the errors on the proofreading task suggesting that they had poorer concentration.

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figures 1 & 2

Finally, urinary norepinephrine and epinephrine levels yielded comparable results. The means from these measures indicated that TMI subjects with lower perceived control exhibited higher levels of arousal than did any of the other subject.

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table 3

Although control-related problems probably do not account for all of the difficulties at TMI, these data indicate that they may play a role in the stress response. But, perhaps as important is the fact that threats at the crippled plant have remained despite clean-up activities. There is a more or less constant threat of exposure to radiation as work on the the crippled reactor has progressed.

Therefore, the consequences of the event may have persisted because of the nuclear nature of the accident. Some of the residents fear that they have been exposed to radiation, and not

only were they powerless to do anything to prevent the exposure, they are currently unable to do anything to counteract the possible long-term consequences of that exposure. In fact, not only did TMI residents express more concern about possible radiation leaks, they reported more concern about the threat to their personal health and more concern about the threat to the health of their family members.

TMI still continues to pose problems for many of the area residents. We have been able to document a persistent stress response, psychologically, behaviorally and biochemically, more than 2 years after the accident. These problems may be partly explained by the nature of the accident. Technological disasters are not planned for in the same way as natural disasters and hence threaten control more directly. In fact, we have data that suggest that control related problems exacerbated the stress response. TMI was also unique in that it posed the additional threat of radiation exposure. Many of the residents fear the future consequences of this exposure and are uncertain of the future costs of that exposure. This uncertainty may have exacerbated the loss of control experienced by the subjects. All of these aspects of the situation have been responsible in part for the continuing stress experienced by the people living near the reactor. With toxic accidents becoming more common it is important to study the psychological problems which may result from this type of incident. The residents at TMI do not even know if the were exposed to radiation, and yet they have continued to exhibit symptoms of stress. We can only imagine what the consequences would be if toxic substances were found in

their drinking water or in areas around their homes. Continuation of this type of research should prove valuable because it will provide additional information about technological and natural disasters and may provide insight on how to deal with the deleterious effects on residents who live near the sights of such accidents.

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Table 1: Mean number of symptoms reported

TMI	Frederick	Dickerson	Oyster Creek
32.7	16.5	21.6	15.6

Table 2: Means for control questions

	feelings of helplessness	feelings of not mattering	feelings of not caring
TMI	1.53	1.74	1.74
Control groups	1.18	1.17	1.23

Table 3: Mean levels for urinary norephinephrine (ng/hr)

	TMI	Frederick
Low Control	2072.64	819.44
High Control	1185.15	623.13

Figure 1: Performance on pyramid task

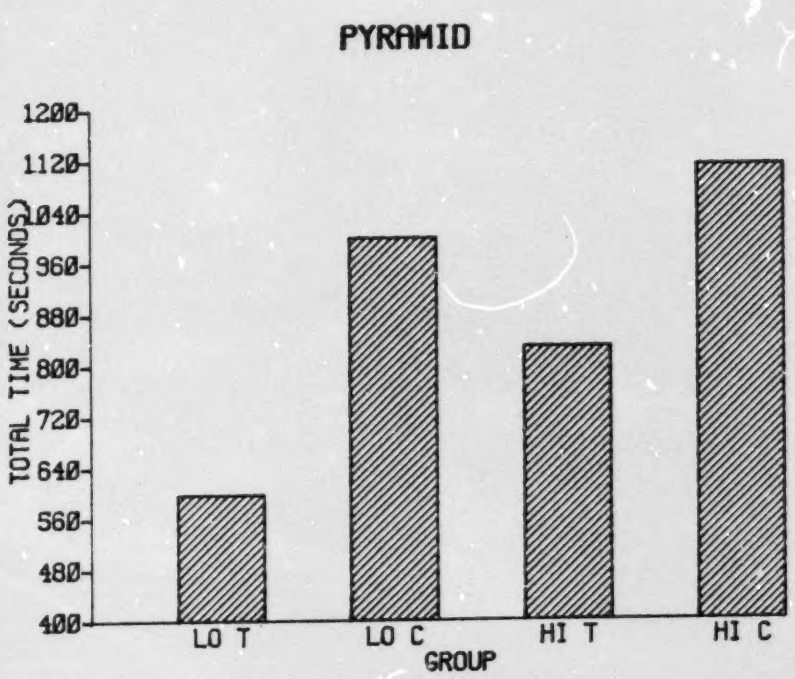
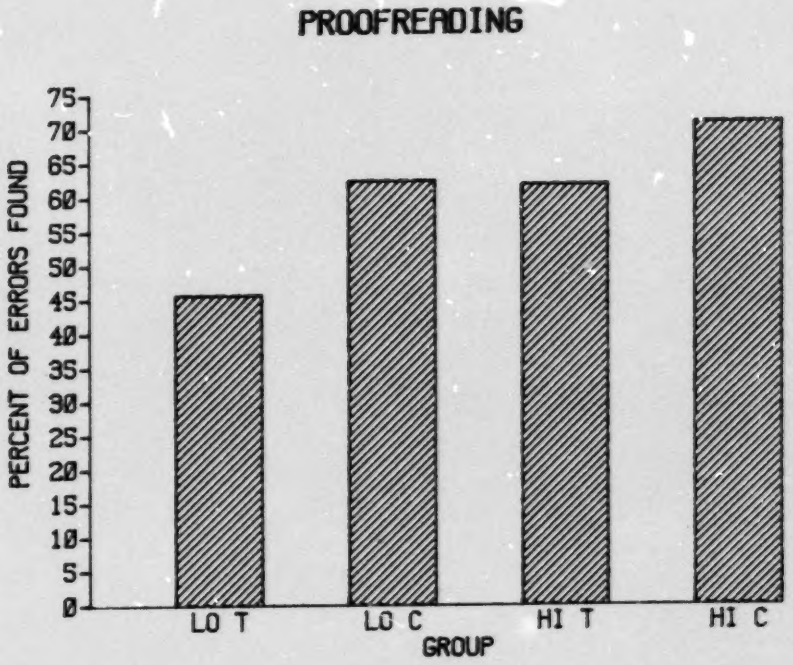


Figure 2: Performance on proofreading



LO T = low control TMI

LO C = low control comparison groups

HI T = high control TMI

HI C = high control comparison groups